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Compressive Sensing based Gender Recognition

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***Abstract*—This paper explores an integration of compressive sensing, curvelet transform, and Principal Component Analysis to develop a robust gender recognition method from face images. Compressive measurements of face images leading to a significant reduction in feature space. Here curvelet transform has been used to represent the face images with prominent edges, curvatures, boundaries and to offer sparse representation to apply compressive measurements on detailed subband. To extract the feature vector, Principal Component Analysis is applied on the reconstructed detailed subband. Performance of the proposed method is evaluated by employing different classifiers. The proposed method efficiently handles the effect of Gaussian noise maintaining high accuracy on gender recognition. Extensive experiments on FERET database, is conducted to substantiate our claim.**

Keywords— Gender recognition, Curvelet transform, Compressive sensing, Principal Component Analysis.

I. Introduction

Gender recognition is an active area of research in computer vision and facing real life challenges for its commercialization. Gender recognition from face images using large set of training data has important real time applications in the fields of security, job distribution etc. It is known that men and women have discriminative facial features, which can be learned for gender recognition. In the present work we concentrate on developing an autonomous gender recognition system using face images by analyzing facial features.

Human perception involves observation of both coarse (global) and detailed (local) features of the face to identify and categorize a person. Currently different types of gender classification methods are available in the literature such as face based, gait based, hand based and many more. However, facial images are widely used for gender classification because facial images probably contain the most common biometric characteristic used by humans to make a personal recognition.

Dimensionality of features plays important role in classification accuracy because learning efficiency is affected due to presence of redundant and irrelevant features in training phase. Moreover, large number of features increases computational cost, slowing down the classification process and creates problem in real time implementation. Therefore, appropriate feature extraction and feature selection methods together improve gender classification accuracy, which have been dealt in this paper proposing a comprehensive framework.

In 2006, Candes and Tao [1] proposed a new mathematical theory and algorithm of compressed sensing (CS) framework, which is a breakthrough of Nyquist sampling theorem. According to CS theory, the sampling frequency could be far below the Nyquist rate as long as signals are sparse and compressible in the measurement space. CS theory and sparse representation of signals allow processing with few numbers of samples and recovering it with low distortion. In this paper we present a CS theory based robust gender recognition scheme to solve the real time gender recognition problem.

Objective of this work is to extract the detail edge information utilizing curvelet transform (CT) which is more relevant to recognize the gender and also offers a sparse domain to reduce the storage space of input images. This paper actually proposes an integrated framework using CS, CT and Principal Component Analysis (PCA) for recognition of gender. PCA has been applied on reconstructed detail subband images to select important features with low dimensional space.

The paper is organized as follows: Section II presents a brief review of gender recognition method, Section III presents the scope and contributions of the proposed method. Section IV describes the proposed gender recognition method and in Section V results are discussed. Section VI concludes the paper.

II. Literature Review

Feature extraction methods for gender recognition can be broadly classified into two categories: geometric approaches and appearance based approaches. Dimension of feature vector increases when pixel intensity is used as features resulting increase of the computational time of recognition as well. Dimension reduction technique such as PCA [2], [3] provides a representation of image in reduced dimension space. Santana et al. [4] proposed a PCA based gender recognition method, where Support Vector Machine (SVM) is used for classification. Two dimensional PCA (2DPCA) is an extension of PCA, used for dimension reduction of feature vector. Lu et al. proposed a 2DPCA based expression invariant gender recognition method in [5]. Gender recognition includes Linear Discriminant analysis (LDA) [6] and Independent Componant Analysis (ICA) [7].

In 2002 Ojala et al. [8] introduced a new texture descriptor, Local Binary Pattern (LBP) for grayscale images. In [9] an LBP based feature extraction technique is proposed for recognition of gender. After dividing the face image into equal sized blocks, LBP is applied for multi-view gender classification. Alexandre [10] combined LBP with intensity and shape features using a multiscale fusion approach. In [11], LBP is combined with contrast information for gender classification where local contrast histograms are used as

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rotation invariant features. Mayo et al. [12] used statistical features such as mean, variance, skew and kurtosis together with LBP. Different enhancements inspired by LBP have been proposed to solve the problem of gender recognition [13],[14],[15],[16].

In order to recognize gender from a face image, it is important to extract all available gender related information from the image and analyzing the information which describes the image. Wavelet Transform (WT) [17] is an ideal tool to analyze the images, ensuring extraction of detail information from high frequency coefficients. CWT and SVM are used for classifying the gender [18], [19] from the facial images and compared with DWT, RADON along with SVM. In [19] Dyadic Wavelet Transform (DyWT) is used for face description. Here integrating DyWT and LBP, a new feature descriptor DyWT-LBP is proposed for gender recognition. DyWT is a kind of translation invariant WT which has a better potential for detection than DWT. Sun et al. [20] showed that feature selection is an important issue for gender classification. An appearance-based method for identifying the gender has been proposed in [21] using facial images on the basis of a pixel-pattern-based texture feature (PPBTF). In [22] two state-of-the-art texture descriptors, the LBP and Weber's law descriptor (WLD) are proposed for gender classification. For feature selection, the local Gabor binary pattern is combined with local discriminative analysis leads to significant improvement in classification.

Recently-emerged CS theory, which originally aims to address signal sensing and coding problems, has shown tremendous potential for other problems like pattern recognition. Chen et al. [23] presented a new technique for gender recognition utilizing the distributed compressive sensing theory and joint sparse model (JSM) for efficient coding of multiple inter-correlated signals. However, curse of dimensionality of feature space is another challenge to solve classification problem with minimum error rate. To solve the dimensionality issue we have presented a CS based gender recognition scheme.

III. Scope and Contributions

In most of the CS based recognition problem, CS has been used to improve the classifier performance. Different from the existing methods, the proposed technique, reduce the storage space of database and efficiently handle the gender recognition with high accuracy. The major contributions of the paper are as follows:

i) A new framework of gender recognition scheme is proposed, where CT plays a dual role, (a) extraction of detail edge information and (b) sparsification of input face images.
ii) For faster implementation we use Smoothed Projected Landweber (SPL) for CS reconstruction.
iii) We propose a CS based gender recognition framework which improves recognition accuracy.
iv) We perform extensive experiments on publicly available face data set FERET. We computed the performance of the proposed method using, K-Nearest Neighbor (KNN), neural network (NN), Naive Bayes (NB) and Support Vector Machine (SVM) classifiers.

IV. Proposed Method

In this section a CS based efficient gender detection framework has been proposed. The flow diagram of the proposed gender recognition scheme is shown in Fig. 1.

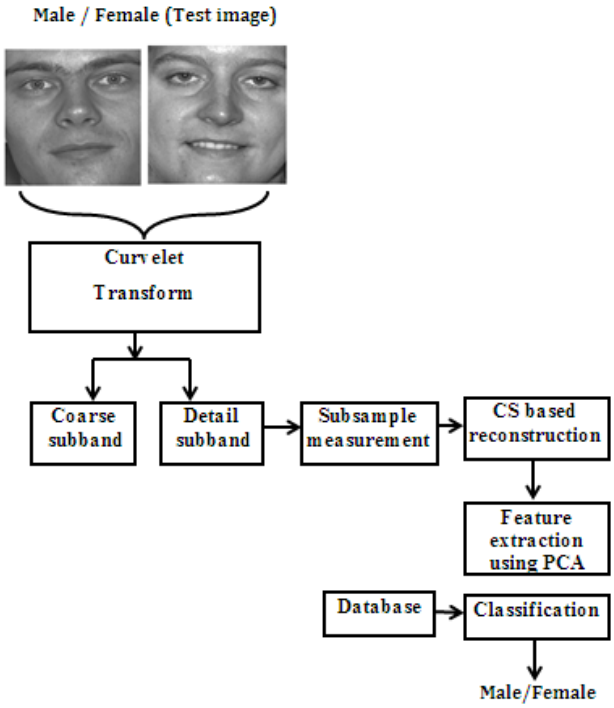

Fig. 1. Flow diagram of CS based gender recognition.

CT is a suitable basis function to sparsify the signal, because most of the coefficients are close to zero after signal transformation. Beside CT can capture better edge and directional information of image compare to other transforms. At the first step each face image (male and female) is decomposed using CT considering scale of 2 and angle 8. Then extracting detail subband different percentage of samples (PS) are chosen and the subband images are reconstructed using CS based technique. For efficient reconstruction smoothed projected landweber (SPL) [24] method is used. Features are extracted in low dimensional space by applying PCA and different classifiers are used to detect the gender.

V. Results and Discussions

We evaluated the performance of the proposed algorithm on facial image database: FERET. The FERET [25] database contains frontal, left or right profile images and could have some variations in pose, expression and lightning. FERET database contains 11,338 images of 994 individuals and consists of different subsets such as frontal images (fa, fb) of different expressions, quarter left (ql), quarter right (qr), profile left (pl), profile right (pr), half left (hl), half right (hr) and rotated images (ra, rb, rc).

In our experiments we use frontal, aligned and images of various pose and different expression (fa, fb, hl, hr subset images). During experiment we choose 600 images (mixed of fa, fb, hl, hr subset) among which 200 are used as test images.

Table I demonstrates classification accuracy of FERET database for PC=50 using KNN classifier. In KNN classifier we have considered three distance measures, which are euclidean, cityblock and cosine. From this table it is also noted that the maximum gender recognition accuracy is 97.78% for PC=50 (for euclidean and city block distance measure). The recognition rate for other classifiers are shown in Table II, considering PC=50 and PS=90%. SVM classifier provides maximum recognition accuracy i.e. 98.33% for RBF kernel function as shown in Table II. The ROC curve for SVM classifier is shown in Fig. 2.

TABLE I. GENDER RECOGNITION RATE OF FERET DATABASE USING KNN CLASSIFIER FOR PC=50

PS	*Euclidean*	*Cityblock*	*Cosine*
10%	77.78%	77.78%	77.78%
20%	86.67%	85.56%	85.56%
30%	92.22%	93.33%	93.33%
40%	92.22%	91.11%	94.44%
50%	94.44%	95.56%	95.56%
60%	95.56%	95.56%	96.67%
70%	97.78%	95.56%	96.67%
80%	97.54%	95.56%	95.56%
90%	97.78%	97.78%	96.67%

TABLE II. RECOGNITION RATE OF FERET DATABASE

Classifier	*Recognition rate in percentage*
Naive Bayes	94.77%
Linear SVM	96.44%
Neural Network	97.66%
SVM with RBF	98.33%
Simple logistic	95.88%

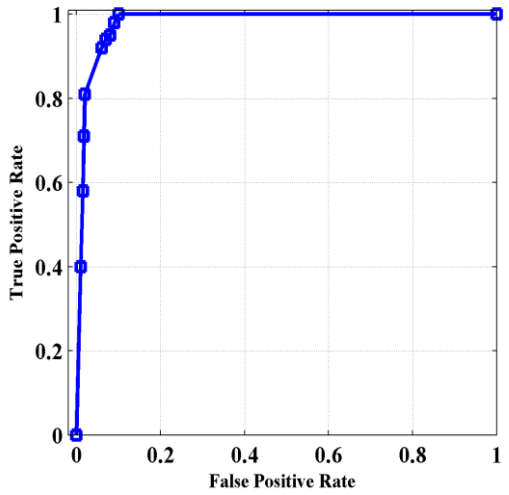

Fig. 2. ROC curve for SVM classifier

In order to observe the dependence of recognition rate on two parameters (feature dimension or PC value and PS value), we should trade-off the parameters and the graphical representation will become a three dimensional plot, such as shown in Figure 3 and Figure 4. Figure 3 and Figure 4 show how the recognition rate changes according to the changes of the feature dimension and PS value for KNN classifier (using city block distance). Figure 3, shows that the best recognition rate 97.78% is obtained when the feature dimension is set to 50 and PS= 70%. In case of Fig. 4 the maximum recognition rate 97.78% is obtained for feature dimension equal to 50 and PS=90%.

Recognition performance of the proposed method is studied for various degree of noise contamination on the face images. Gaussian noise is added with zero mean and varied variance. The classification results for different values of variance are presented in Table IV considering city block distance measure. We observe that the proposed method correctly classifies the noisy test images where accuracy has been varied by maximum 1%.

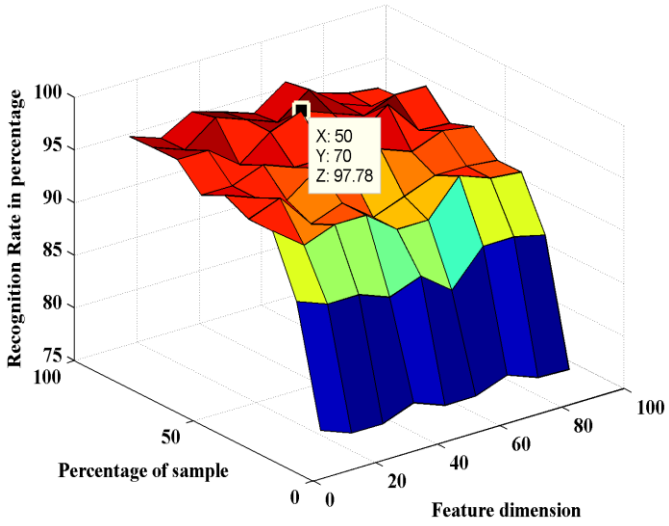

Fig. 3. Recognition Rate vs. feature dimension vs. PS for KNN classifier

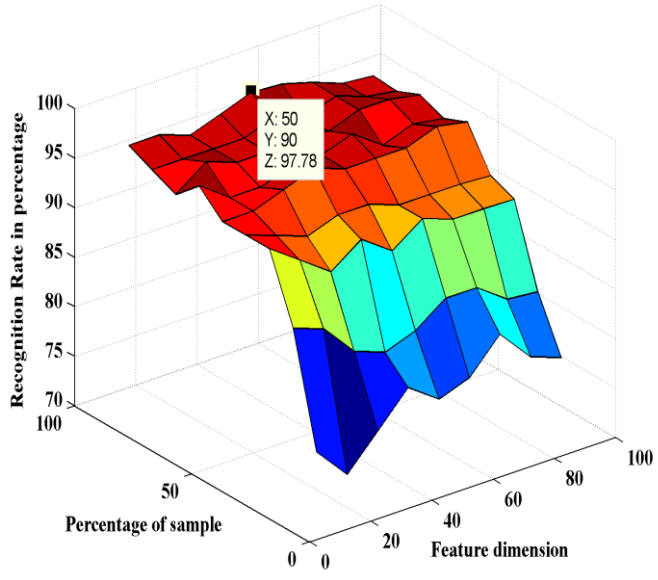

Fig. 4. Recognition Rate vs. feature dimension vs. PS for KNN classifier

Comparisons with the existing methods are summarized in Table III. In Table III proposed method is compared with [26], [27] and [28]. The proposed method provide better recognition rate compared to [26], [27] and [28].

TABLE III. COMPARISON USING FERET DATABASE

Method	Maximum recognition rate in percentage
NN [26]	90.07%
SVM [26]	84.44%
LDA+Gabor wavelet [27]	93.33%
Wavelet+PCA[28]	93%
Proposed method	97.78%(for KNN) 98.33%(for SVM)

TABLE IV. EFFECT OF NOISE ON FERET DATABASE (FOR PS=90%, PC=50)

Variance	Average recognition rate in percentage
0.01	97.75%
0.02	97.71%
0.1	97.26%
0.2	96.73%

VI. Conclusions

The paper proposed a facial feature based gender detection method in CS domain. The proposed integrated framework includes compact representation, dimensionality reduction and promising results while evaluation classification accuracy using different classifiers. If we store the database by randomly selecting percentage of samples from the detail subband, it saves storage space. Due to low dimension of feature, it can be used for real time applications. The experimental results on FERET data set clearly demonstrate that our method performs better compare to other methods. In the work, effect of PS on gender recognition is learned by varying the PC and obtained the maximum recognition rate 98.33% for PC=50 and PS=90% (SVM with RBF). The proposed method is robust under the effect of Gaussian noise.

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